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has inherited from its original protoplasmic ancestor an adjustment of colloidal equilibrium to those electrolytes which were present in sea-water at the time that protoplasmic material first came into being. In other words we may say that electrolytes play, and always have played, an extremely important rôle in conditioning the form and structure, and maintaining the equilibrium of the complex colloidal system which we designate as living protoplasm. For further details regarding these and other experiments, and the methods employed, reference must be made to a paper in the May number of the *Journal of Physical Chemistry* and to other papers which will shortly appear in the *Journal of Physical Chemistry*, the *American Journal of Physiology*, etc.

In conclusion the writer wishes to acknowledge his great indebtedness to Mr. F. West for his cooperation in the conduct of the experiments recorded in this communication.

G. H. A. CLOWES

#### THE ORGANIZATION OF THE PACIFIC PHYSICAL SOCIETY

THE first meeting of the Pacific Physical Society was called to order by Professor Fernando Sanford at 3 o'clock on March 4 in Room 370, Stanford University Quadrangle. Forty members of the various departments of physics, physical chemistry and chemistry of the Pacific coast universities were present.

Professor E. P. Lewis, of the University of California, was called to the chair, and the following program was presented:

*The Electromotive Force produced by the Acceleration of Metals:* RICHARD C. TOLMAN and T. DALE STEWART.

This paper described some experiments on the mass or inertia of the carriers of electricity in metals. Similar effects have been looked for by previous investigators, Maxwell,<sup>1</sup> Lodge<sup>2</sup> and Nichols,<sup>3</sup> without apparatus sensitive enough for the purpose.

<sup>1</sup> Maxwell, "Treatise on Electricity and Magnetism," 3d ed. (1892); Vol. II., pp. 211 *et seq.*

<sup>2</sup> Lodge, "Modern Views of Electricity," 3d ed. (1907), p. 89.

<sup>3</sup> Nichols, *Physik. Z.*, 7, p. 640 (1906).

A coil of wire was rotated about its axis and suddenly brought to rest. The two ends of the rotating coil were connected through an external circuit with a highly sensitive ballistic galvanometer and the deflection of the galvanometer noted when the coil was stopped, the pulse of electricity thus measured being produced by the tendency of the electrons in the wire to continue in motion after the rest of the coil was at rest. A number of serious accidental effects had to be eliminated.

From the results of the measurements it was possible to calculate the effective mass of the electron in copper, silver and aluminum, the values obtained being not far different from that of the mass of the electron in free space.

The authors believe that their results are in accord with the "free electron" theory of metallic conduction and present serious obstacles to Sir J. J. Thomson's<sup>4</sup> recent theory of the conducting process in metals.

*Contact Electromotive Force of Amalgamated Metals:* F. J. ROGERS.

*Electromotive Force of Metallic Sulphide Electrodes:* S. W. YOUNG and W. E. BURKE.

*Change of Potential of the Same Metal in Different Electrolytic Solutions:* PHILO F. HAMMOND.

Voltaic cells were formed by using platinum electrodes for both the cathode and the anode, but with different salt solutions surrounding each electrode, the two solutions being connected by a capillary tube or a gelatine partition. One tenth normal solutions were used in every case. Each

Metallic Ion in Nitrate Solution Used	When Measured Against Silver Nitrate	When Measured Against Potassium Nitrate	Single Electrode Potentials with Silver Reduced to Zero
Ag .....	0	0.658	0
Fe <sup>6</sup> .....	0.114	0.544	?
Cu .....	0.392	0.266	0.44
H .....	0.509	0.149	0.77
Pb .....	0.537	0.121	0.92
Ni .....	0.560	0.098	0.985
Co .....	0.565	0.093	0.99
Fe <sup>6</sup> .....	?	?	1.10
Cd .....	0.594	0.064	1.19
Zn .....	0.600	0.058	1.54
Mg .....	0.623	0.035	2.54
Ca .....	0.632	0.026	2.94
Ba .....	0.647	0.010	3.44
Na .....	0.653	0.005	3.90
K .....	0.658	0	3.94

<sup>4</sup> Sir J. J. Thomson, *Phil. Mag.*, 30, 192 (1915); see also Richardson, *Ibid.*, 30, 295 (1915).

<sup>5</sup> Ferric nitrate.

<sup>6</sup> Ferrous nitrate.

salt solution was measured against both silver nitrate and potassium nitrate.

After making certain corrections the above results were obtained from the measured differences of potential of the two electrodes.

Column three was derived from tables.

A curve was plotted using column one as abscissæ and column three as ordinates.

Notice that the ferric ion does not fall in the position usually given to iron, but in a position near the silver, actually between antimony and mercury.

*The Pressure of Sound Waves:* E. P. LEWIS.

*The Passive State of Iron in Nitric Acid:* JOSEPH G. BROWN.

It seems evident that the only hope of explaining the passive state of metals lies in the detailed study of the process by which some particular metal becomes passive in some particular solution. Accordingly such a study has been made for iron in nitric acid solutions. The E.M.F. of the primary cell: Iron/ $\text{HNO}_3$  solution/concentrated  $\text{HNO}_3$ /platinum, has been measured at room temperature from the instant that it was made until it reached a steady state, using eight densities ranging from 1.01 to 1.41, both with the iron at rest and in motion. Observations were made with a low power microscope upon the changes which took place on and around the iron.

The results show that the ferrous oxide which forms on the iron at the start in all acid densities does not affect the E.M.F. of the cell, but the liquid products do. If the iron is kept at rest in acids up to 1.17 the E.M.F. is increased by the presence of the ferrous nitrate, while in acids denser than 1.17 the E.M.F. is lowered by some other product which forms a bright red liquid film over the oxidized surface of the iron. It is thought that this may be the unstable compound formed by the absorption of nitric oxide by ferrous nitrate, and the existence of this compound determines the semi-passive state.

In acids of greater density than 1.25 there is an explosive reaction between the ferrous oxide and the red liquid, after which the iron is in the passive state. The E.M.F. falls very quickly to a minimum and then rises very slowly to an extremely constant value.

It seems probable that both the ferrous and ferric reactions take place in acids of all densities, but in those greater than 1.25 the ferrous reaction may be quenched by the sudden reaction

between the ferrous oxide and the red liquid, while the ferric reaction remains.

There is no indication of the existence of any kind of a film after the passive state is reached, but the gradual change in E.M.F. seems to indicate the expulsion of a gas from the iron after the state is reached.

If the explanation given is correct it allows the interesting conclusion that iron is "active" whenever the conditions are such that the ferrous ions are formed, but it is "passive" whenever these ions are not formed. This means that iron is essentially ferric and the chemical and electrical action of iron under ordinary circumstances is due to the existence, or formation, of ferrous iron at the surface. The E.M.F. measurements obtained would thus place ferrous iron in the electrode potential series between cadmium and cobalt, which is usually ascribed to iron, while ferric iron falls between antimony and mercury.

The fact that all those properties of iron which depend upon its cohesion make it more like platinum than like zinc, and the fact that comparisons of the potential of the same metal in ferrous and ferric salts place the ferrous and ferric iron in these same positions in the series, seem to confirm the conclusion.

If the significant thing about a valence is a number of electrons, it would seem that the surface molecules lost an electron under certain conditions but not under other conditions.

*Conductivity of Paints:* RAYMOND B. ABBOTT.

*A Possible Method for the Detection of Gravitational Effect on Electrons:* LLOYD T. JONES.

*A Formula for Computing a Cohesion Constant:* P. A. ROSS.

At the Berkeley meeting of the American Physical Society in 1915 a paper was presented by the writer on the "Law of Cohesion in Mercury," in which it was found that the cohesion forces in mercury varied inversely as the sixth power of the distance. A value of the cohesion force was computed from the specific heat and coefficient of expansion which integrated on vaporization to a value agreeing well with the latent heat of vaporization.

In the present paper it is shown that from the principle of equipartition of energy in a vapor the same cohesion constant may be computed, the formula being

$$K = 7.5 \frac{p}{dD^{5/3}} \cdot \left( \frac{M}{N} \right)^{2/3},$$

where  $p$  is the vapor pressure;  $M$ , molecular weight;  $N$ , number of molecules per gram molecule;  $d$ , density of the vapor;  $D$ , density of the liquid;  $K$ , cohesion force between a vapor molecule and the liquid surface.

From this equation another constant,  $F$ , representing the force between two single molecules was found to be given by the equation

$$F = \frac{pM^{3/3}}{dD},$$

where the letters have the same meanings as before. At the critical point this becomes

$$F = \frac{pM^{3/3}}{D^2}.$$

This constant is directly proportional to the constant "a" in Van der Waals's equation and nearly proportional to the Rankine, Heydewiller and Kleeman constants.

*A New Automatic Mercury Pump:* W. P. ROOP and L. T. JONES.

*Two Small Communications on Galvanometers:* W. P. ROOP.

(a) The reduction factor and resistance of a sensitive galvanometer may be quickly and conveniently determined by means of a decade bridge. Galvanometer and battery are connected to the appropriate binding posts, as in the ordinary use of the bridge. The binding posts to which the unknown resistance is ordinarily connected are left free. Two settings of rheostat resistance and the corresponding galvanometer readings yield the required result.

Approximations are as follows: One ratio arm is neglected in comparison with the other. Battery resistance is neglected in comparison with that of the high ratio arm. Battery E.M.F. is taken as constant. The deflections of the galvanometer are supposed proportional to current. Failure to meet this last condition can be remedied by applying a process of successive approximation to the calculations.

(b) The sensitiveness of a galvanometer may be doubled by doubling the scale distance and placing the telescope close to the mirror. As compared with other means of increasing the sensitiveness<sup>7</sup> this scheme has the following advantages: It requires no change in the galvanometer. It brings the observer close to the instrument. It enlarges, rather than diminishes, the field of view, or, if desired, permits the use of a smaller mirror.

<sup>7</sup> Geiger, *Physikalische Zeitschrift*, January, 1911.

It introduces none of the difficulties of the other method which arise in multiple reflection.

*Some Properties of Thin Films:* W. P. ROOP.

An attempt to observe a change in ohmic resistance of a thin film on illumination with ultraviolet light resulted negatively. Such a change might be anticipated as a result of photoelectric emission. Diminution in density of free electrons might increase resistance, or liberation of bound electrons might result in decrease.

Other phenomena were observed, however, for which no simple explanation has been found. These include: (a) Spontaneous change in resistance of the film. (b) Negative temperature coefficient. (c) A quasi-polarization effect. The film was connected like a condenser, first with a dry cell, and then with a galvanometer. The galvanometer showed ballistic deflections which diminished approximately logarithmically with increasing time interval between disconnection from cell and discharge. The half-value period was about two seconds. (d) Fluctuations in the resistance of the film. In a typical case, there was a variation of the order of 1 per cent. in the resistance of a film of  $2 \times 10^6$  ohms. The fluctuation was entirely spontaneous, uninfluenced by small temperature changes and by the nature of the gas in contact with the film. It covered a wider range at higher resistances.

Oxidation has an undoubted effect on the phenomena observed. All were present, however, in high vacuum and hydrogen as well as in air. Substances most used were nickel and zinc. Observable tarnish of the surface was in no case apparent.

A recess was declared at 6 o'clock in order to enjoy a delightful dinner, served in the Faculty Club house on the campus. After the dinner members listened to the paper by Professor Sanford.

*The Specific Inductive Capacity of Certain Metals:* FERNANDO SANFORD.

It is well known that in the spectra of a number of metals series of lines have been found whose wave-lengths may all be computed from a simple formula. In all these cases the wave-lengths converge towards a shortest possible wave-length for the series. In the group of the alkali metals a spectral series whose convergence wave-length is shorter than any known wave-length in the spectrum of the respective metal is known for each element. It is assumed in the paper that these convergence wave-lengths represent the shortest wave-lengths that can exist in their respective

atoms, and that the orbital radius of the electron whose vibration frequency would give the convergence number is the true radius of the central positive atom.

Heydweiller has computed the atomic diameter of a large number of elements from the volume occupied by their dissociated ions in a very dilute water solution. Heydweiller's atomic radii are accordingly here taken as the orbital radii of the electrons whose vibration frequencies would give the convergence numbers of Kayser's "Principal Series" in the alkali metals, and the centripetal forces required to hold these convergence electrons in their orbits are calculated. Then, assuming the inverse square law for the attraction between an electron and its central positive charge, the force of attraction upon an electron at unit distance from the center of its orbit is calculated for each element.

If the central positive charges of the atoms were the same for different elements, then these central forces should be the same. They are found not to be the same.

The positive charges of these atoms have previously been computed by the writer from electrolytic data. The charges here computed are not proportional to those formerly computed, hence the assumption that the atoms of the different elements have different specific inductive capacities seems to be justified. These specific inductive capacities may be computed by dividing the charges of the atoms by the respective forces which they exert upon an electron at unit distance.

The specific inductive capacities are calculated in this way for the thirteen elements for which convergence numbers, atomic radii and atomic charges have been computed. Since it is only for the alkali metals that the convergence numbers used are known to belong to the principal, or inner, spectral series, it is only to these elements that we can be sure that the above arguments apply. However, the computed specific inductive capacities are proportional to the serial numbers of Rydberg for ten of the thirteen elements, and for the other three, viz.; zinc, cadmium and thallium, they increase with the serial numbers just half as fast as they do in the case of the other elements.

The specific inductive capacities here computed are also shown to vary with the same atomic properties which vary with the measured specific inductive capacities of non-metallic elements.

It is also shown that the specific inductive capacities of these elements are proportional to their

respective atomic radii. This would make the centripetal force upon electrons revolving about and very near to these different atoms proportional to the inverse third power of their orbital radii. This is shown to be the relation that must hold in order that the kinetic energy of different electrons shall vary as their frequency, as is assumed in Planck's Law and is apparently shown in the case of electrons expelled by the action of ultra-violet light upon metals.

The *relative* specific inductive capacities which have been calculated as above are given in the following table:

Element <i>k</i>	Element <i>k</i>	Element <i>k</i>
Li ..... 35.9	Mg ..... 134	Zn ..... 190
Na ..... 127	Ca ..... 196	Od ..... 255
K ..... 238	Sr ..... 412	Tl ..... 350
Rb ..... 437	Ag ..... 466	
Cs ..... 567	Cu ..... 346	

Attention is called to the fact that if the orbital radius of the outermost electron of a series be taken as the atomic radius instead of the orbital radius of the innermost electron, it will not change the order of values of the specific inductive capacities calculated as above.

Following the discussion of this paper, the question of a Pacific coast organization was taken up. The chairman of the meeting reported that favorable replies had been received from the science instructors at the universities in Washington, Oregon and Utah. It was decided to form an informal organization to be known as the Pacific Physical Society, looking toward the formation of a section or branch of the American Physical Society in the near future.

RALPH S. MINOR,  
*Permanent Secretary*

## SOCIETIES AND ACADEMIES

### THE AMERICAN MATHEMATICAL SOCIETY

THE one hundred and eighty-fourth regular meeting of the society was held at Columbia University on Saturday, April 29, 1916. The attendance at the two sessions included fifty-one members. President Brown occupied the chair, being relieved by Vice-president E. R. Hedrick. The council announced the election of the following persons to membership in the society: Dr. E. T. Bell, University of Washington; Professor T. R. Eagles, Howard College; Mr. Glenn James, Purdue University; Dr. J. O. Hassler, Chicago, Ill.; Professor G. N. Watson, University College, London; Mr. J. H. Weaver, West Chester, Pa. Six